This paper is not an official document, it is for information only and must not be quoted in any printed publication.

AGRICULTURAL MEMORANDUM NO 904

Time available for grain drying by ambient air

J Cochrane

Much grain is harvested at moisture content above 20% and subsequently dried in store to about 15% moisture content.

Equilibrium relative humidity (ERH) at these levels is approximately 90% and 70% respectively. The purpose of this study is to determine the time available to ventilate the stored grain using unmodified ambient air at relative humidity (RH) of 70% or less and to estimate the extent to which the ambient air must be heated in order to reduce its relative humidity to 70%.

At temperatures above 0°C the variation of saturation vapour pressure (SVP) with temperature can be represented approximately by the curve (Rosenberg):-

$$\log_{10} SVP = 0.02604T + 0.82488 \qquad (1)$$

where T = temperature in deg C

Consider ambient conditions of:-

Temperature = T°C
Relative humidity = RH %
Vapour pressure = VP mbar

then $RH = \frac{VP \times 100}{SVP}$

where SVP = saturation vapour pressure at T°C

or $SVP = \frac{VP \times 100}{RH}$

FH28

Rearranging (1) above:-

$$T = \frac{\log_{10} SVP - 0.82488}{0.02604}$$

$$= \frac{\log_{10} (100\ VP/RH) - 0.82488}{0.02604}$$

To reduce ambient RH to 70% requires that the temperature be raised to T* such that

$$T^* = \frac{\log_{10} (100\ VP/70) - 0.82488}{0.02604}$$

This temperature increase

$$(T^* - T) = \frac{\log_{10} (100\ VP/70) - \log_{10} (100\ VP/RH)}{0.02604}$$

$$= \frac{\log_{10} (100\ VP/70 \quad 100\ VP/RH)}{0.02604}$$

$$\Delta T = \frac{\log_{10} (RH/70)}{0.02604}$$

NB. Based on a curve fitting procedure the expression for SVP is not an exact relationship and the inversion to estimate temperature introduces a further uncertainty. Although the values of Δ T so derived will be accurate enough

for the purposes of this study in that the variations over the country will be reasonably represented, the values should not be used to determine precise energy requirements.

Hourly meteorological data for 10 stations in England - see Fig 11 - have been analysed to give the percentage distribution of T during "day" (06 to 21 H GMT) and "night" (22 to 05 h GMT) July to October 1970 to 1979.

The advantageous position of the eastern half of the country compared with western coastal areas may be seen in a comparison of Honington (Fig 5) with St Mawgan (Fig 8). During August and September no heat is required during about half the daylight hours at Honington while this figure is reduced to about one quarter at St Mawgan. Even at Exeter (Fig 4), with some shelter from the west winds and a less coastal situation, the period of no heat requirement is only about one third of daytime hours. In western coastal areas the heating system would have to be in operation for up to twice as many hours as in the east.

Although ventilating with unmodified air will be beneficial as long as the ambient RH remains less than the grain ERH, the rate of drying increases as the deficit of RH below ERH increases. During night hours, at all ten locations, Δ T is 4° or greater for most of the time indicating an ambient RH of 90% or higher. Thus, ventilating with unmodified air by night is, at best, ineffective and may be positively harmful.

In all areas, the time available for ventilating with unmodified air falls sharply in October and the corresponding requirement for heating increases. It would appear economically sound to plan to complete drying of stored grain before the end of September.

The amount of energy required to raise the temperature of the ambient air is a function of the product of the temperature increase and the time. For example, at Honington in August (Fig 5) the energy required will be proportional to:-

$$(1 \times 6) + (2 \times 7.5) + (3 \times 8) + (4 \times 7.5) + (5 \times 9.5) + (6 \times 9) = 176.5$$

The comparable figure for St Mawgan is 281.5 in August while the September figures are 194 and 290 respectively. Thus, while daytime heating has got to be provided for up to twice as long in the western coastal areas than in the east, the cost of warming the air is only about 50% greater in the west. By night there is little difference between the requirements at these two sites.

Reference

ROSENBERG, N.J., Microclimate: The biological environment. P 131, John Wiley and Sons, 1974.

Any comments should be addressed to the author.

Meteorological Office
ADAS, Cambridge

Figures 1 to 10

Percentage number of hours when temperature of ambient air has to be raised by $\Delta T^{o}C$ to reduce the relative humidity to 70%.

Key

_____ = Day (06 to 21 h GMT)

_ _ _ = Night (22 to 05 h GMT)

T = 0 - no heating required

T = 1 - temperature to be raised by between 0.1 and $1.0^{o}C$ etc.

NB. The histogram columns are superimposed - both solid and broken are raised from the base line.

Figure 11

Location of stations used in the analysis.

Birmingham (Elmdon)

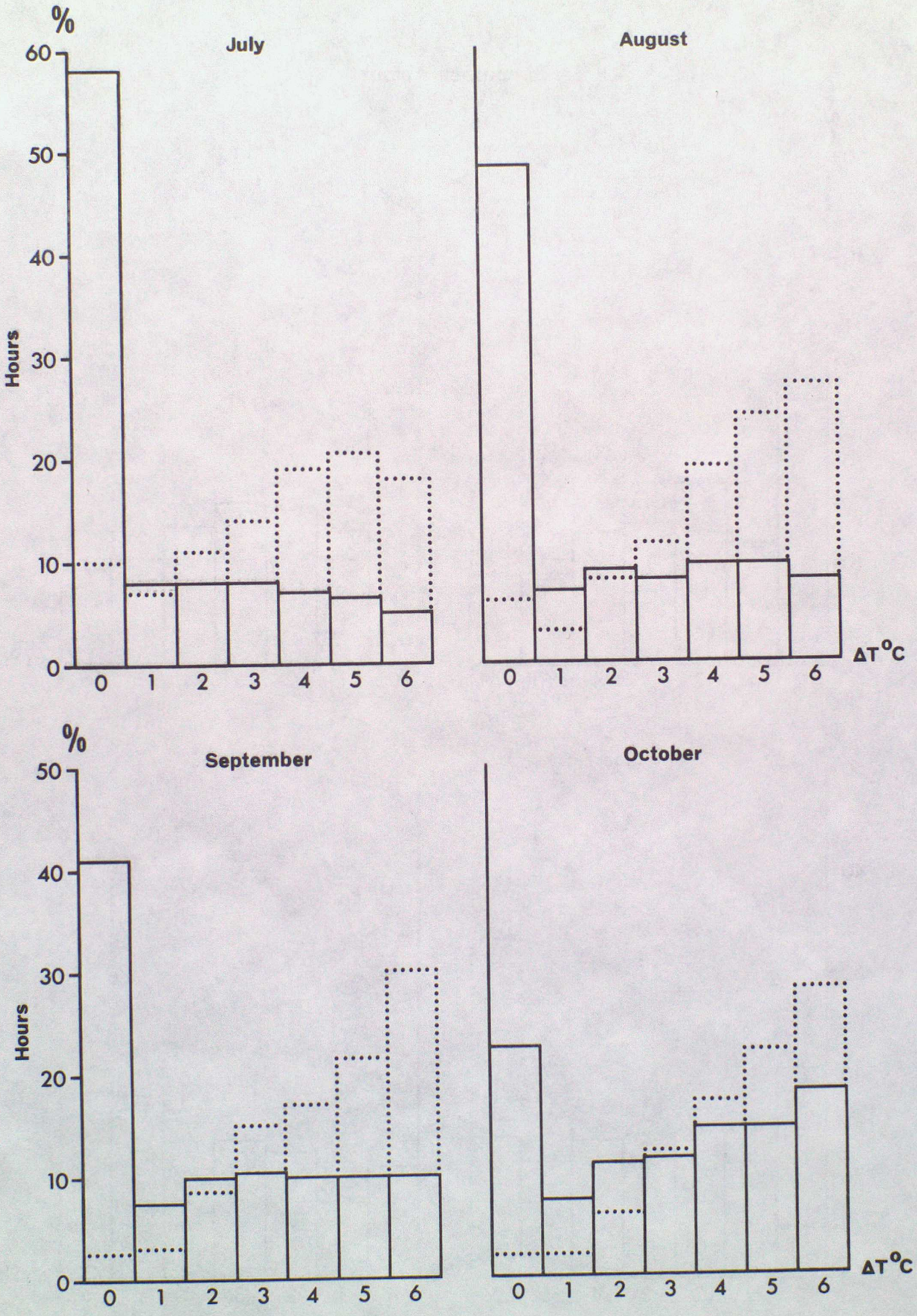

Fig.1

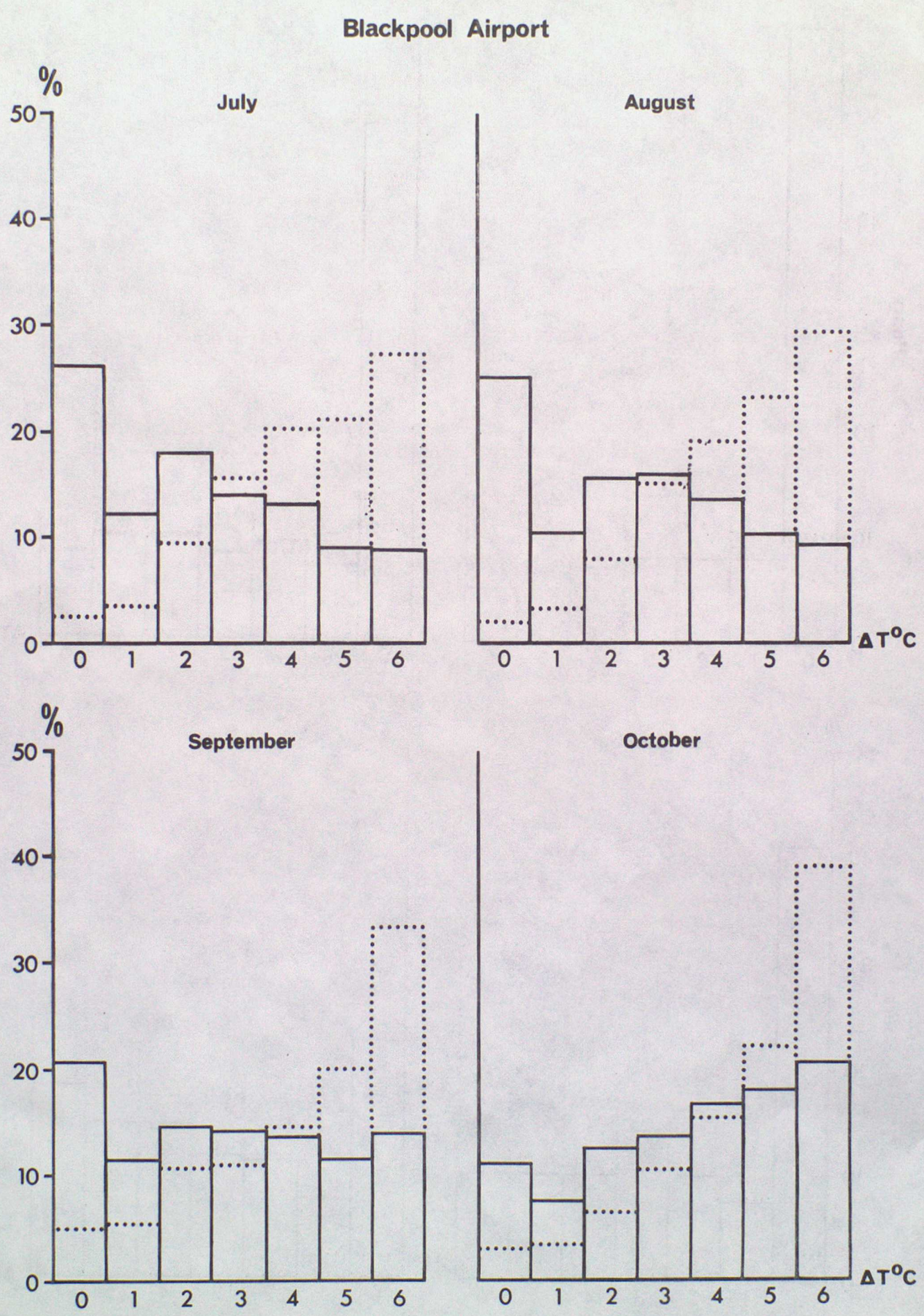
Blackpool Airport
%
July
August
50
40
30
20
10
0
0 1 2 3 4 5 6
ΔT°C
%
September
October
50
40
30
20
10
0
0 1 2 3 4 5 6
ΔT°C

Fig. 2

Boscombe Down

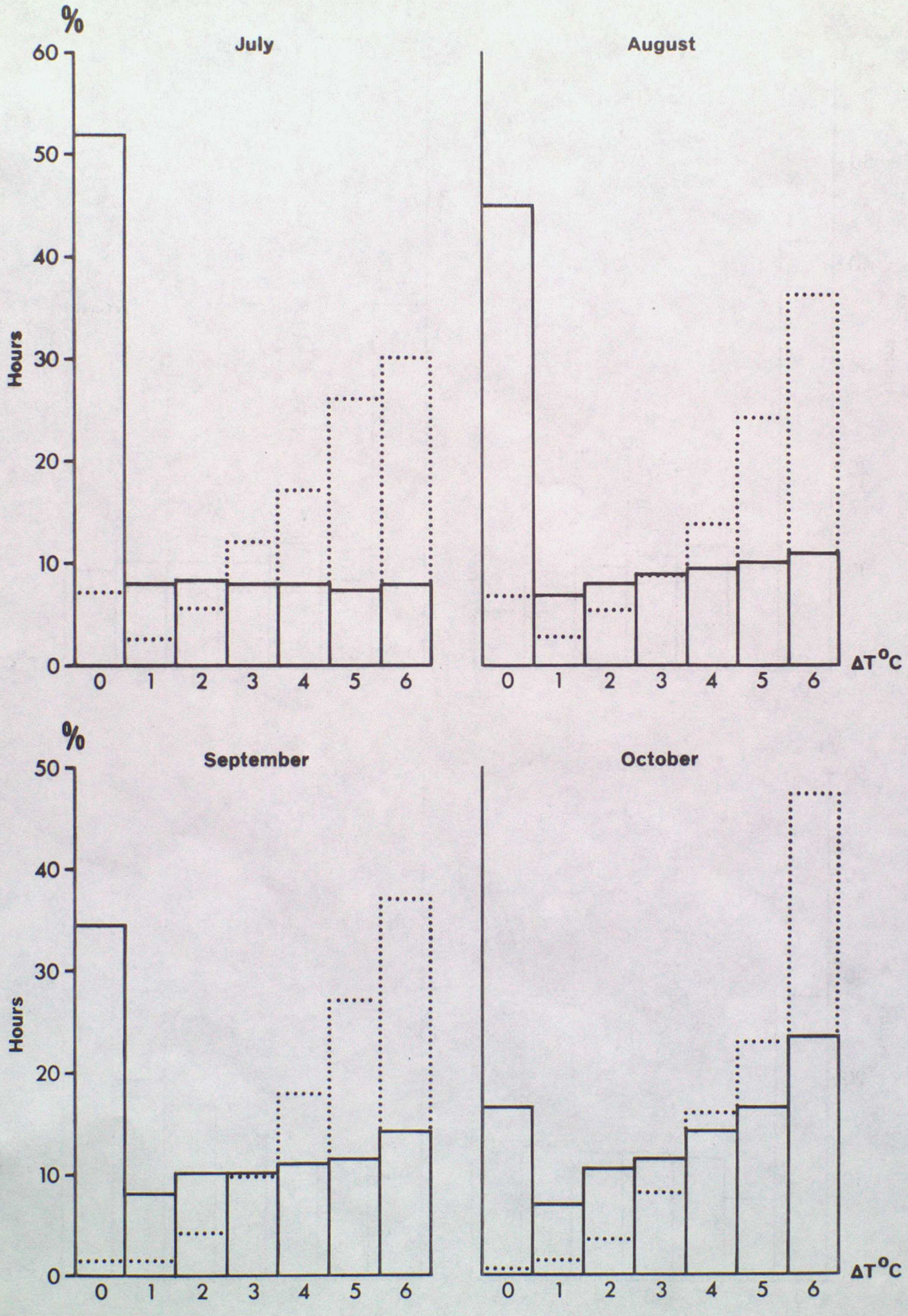

Fig. 3

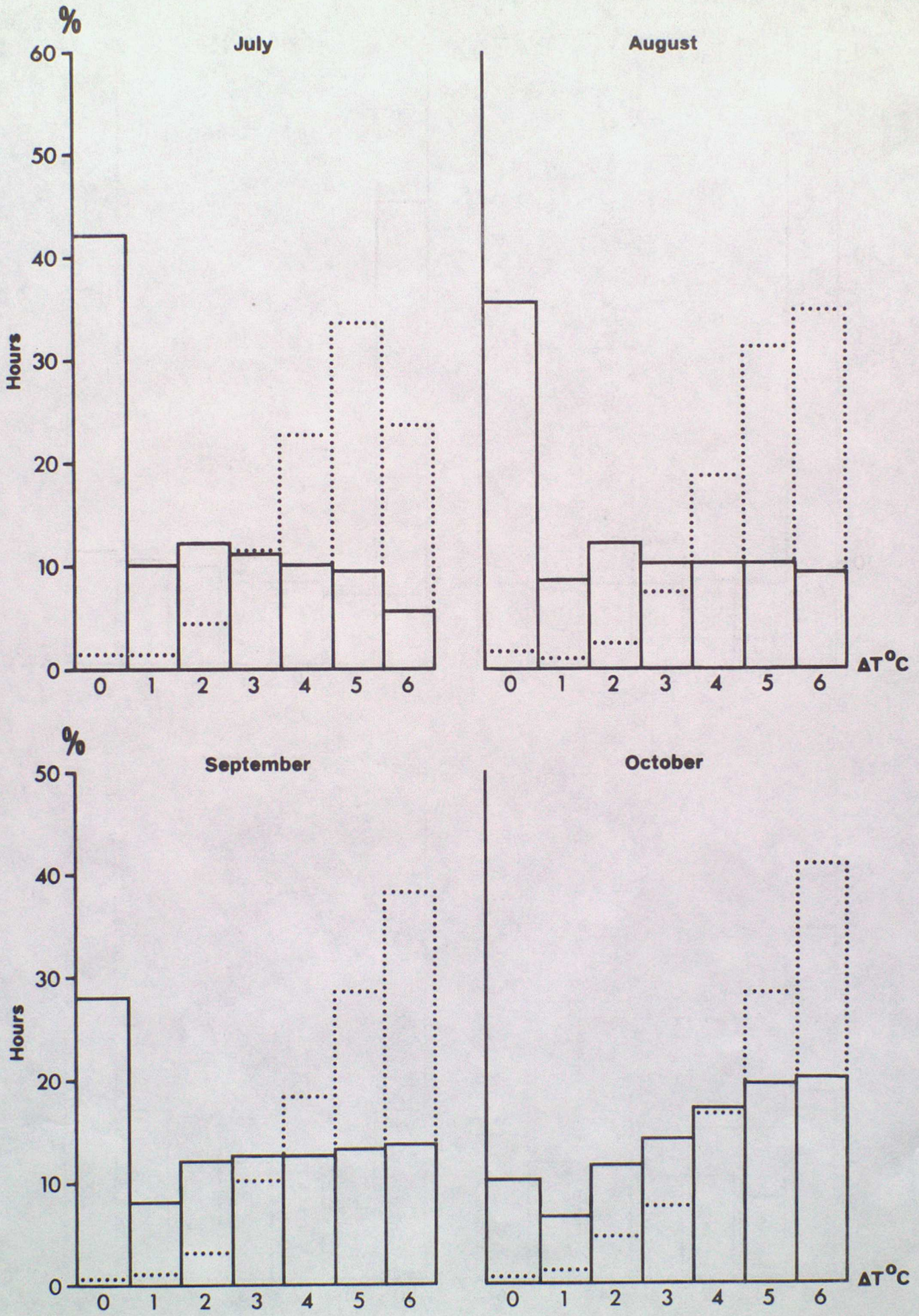
Exeter Airport
%
July
August
60
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C
%
September
October
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C

Fig. 4

Honington

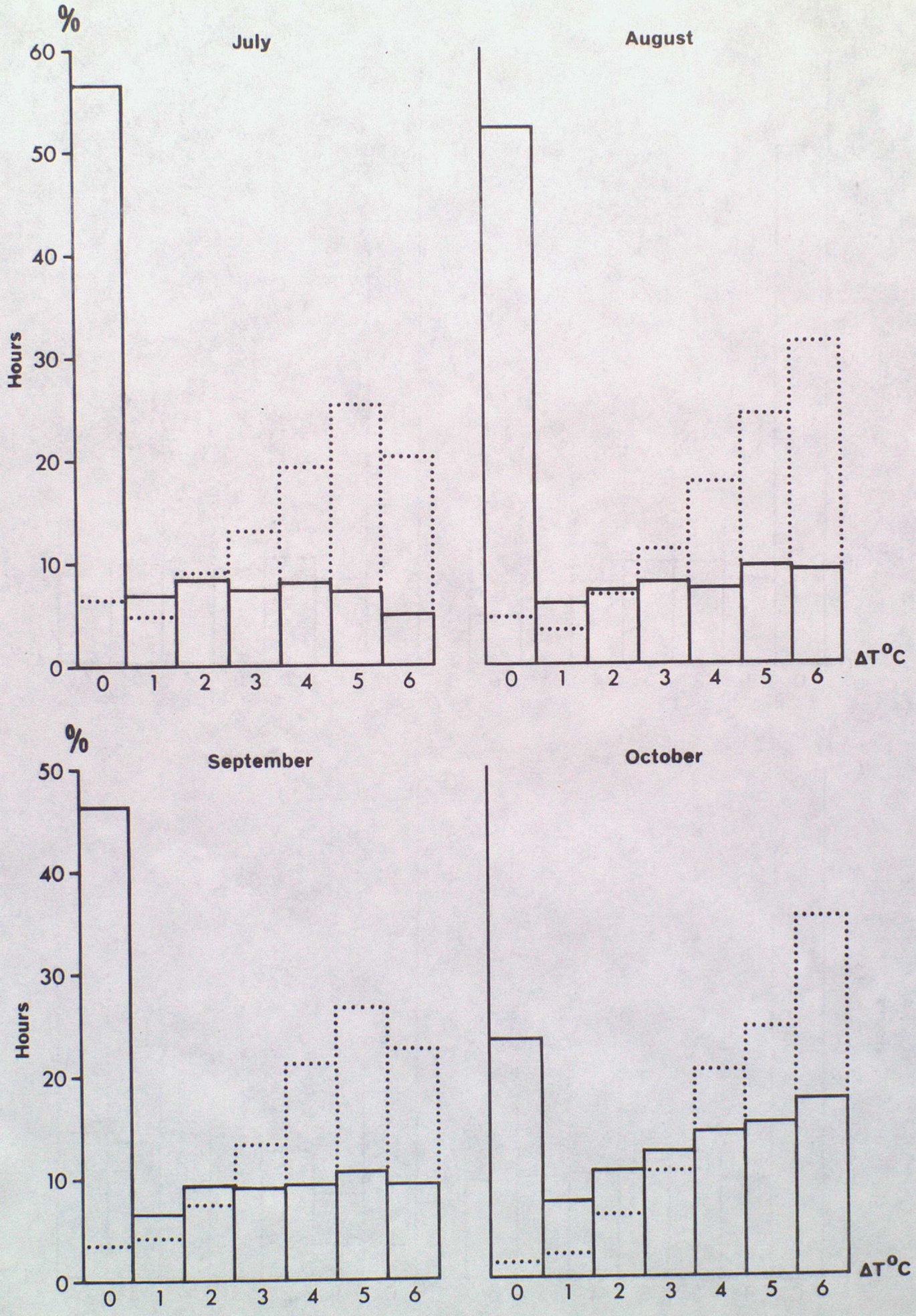

Fig.5

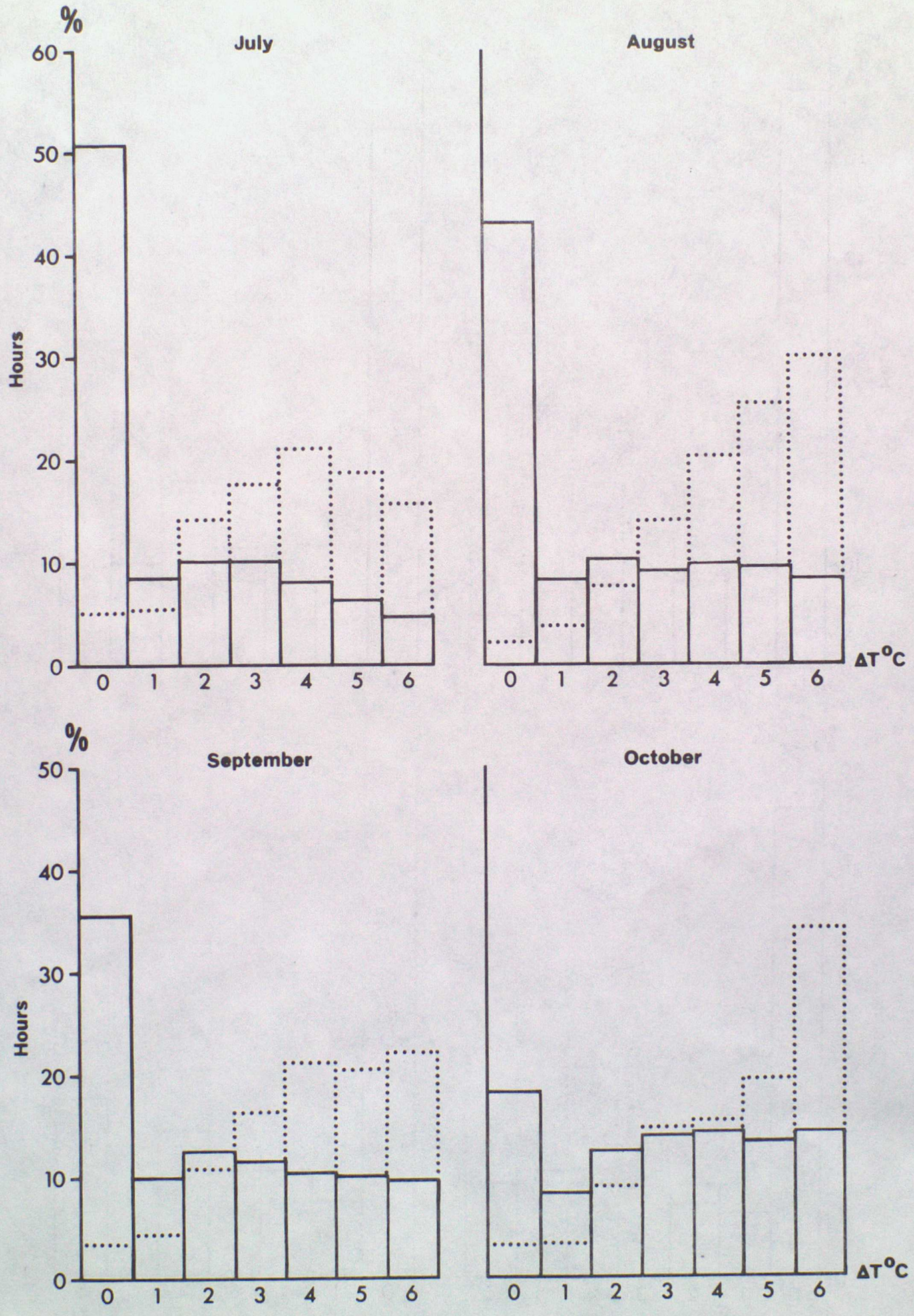
Leeming
%
July
August
60
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C
%
September
October
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C

Fig.6

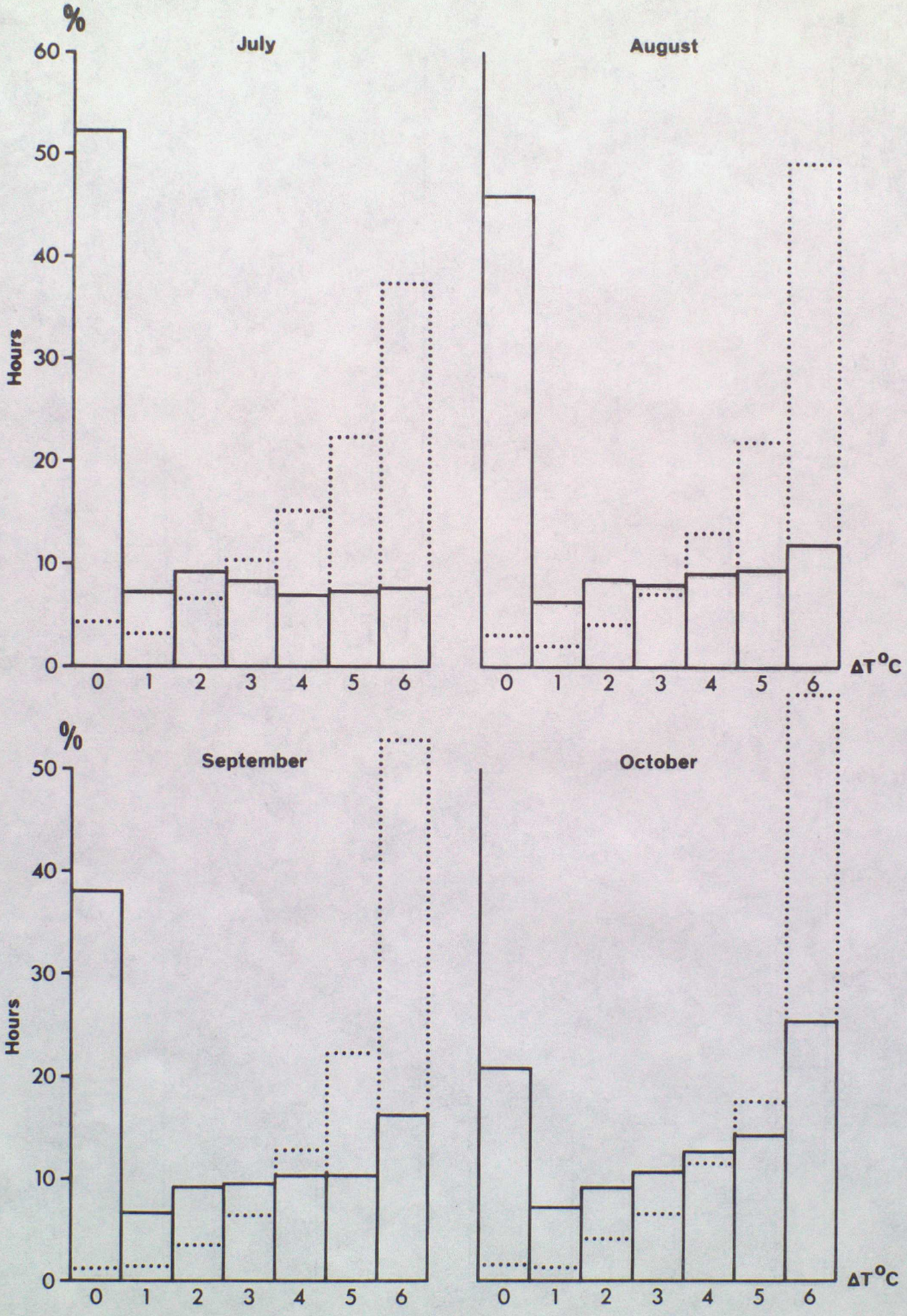
London (Gatwick) Airport
%
July
August
60
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C
%
September
October
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C

Fig. 7

St. Mawgan

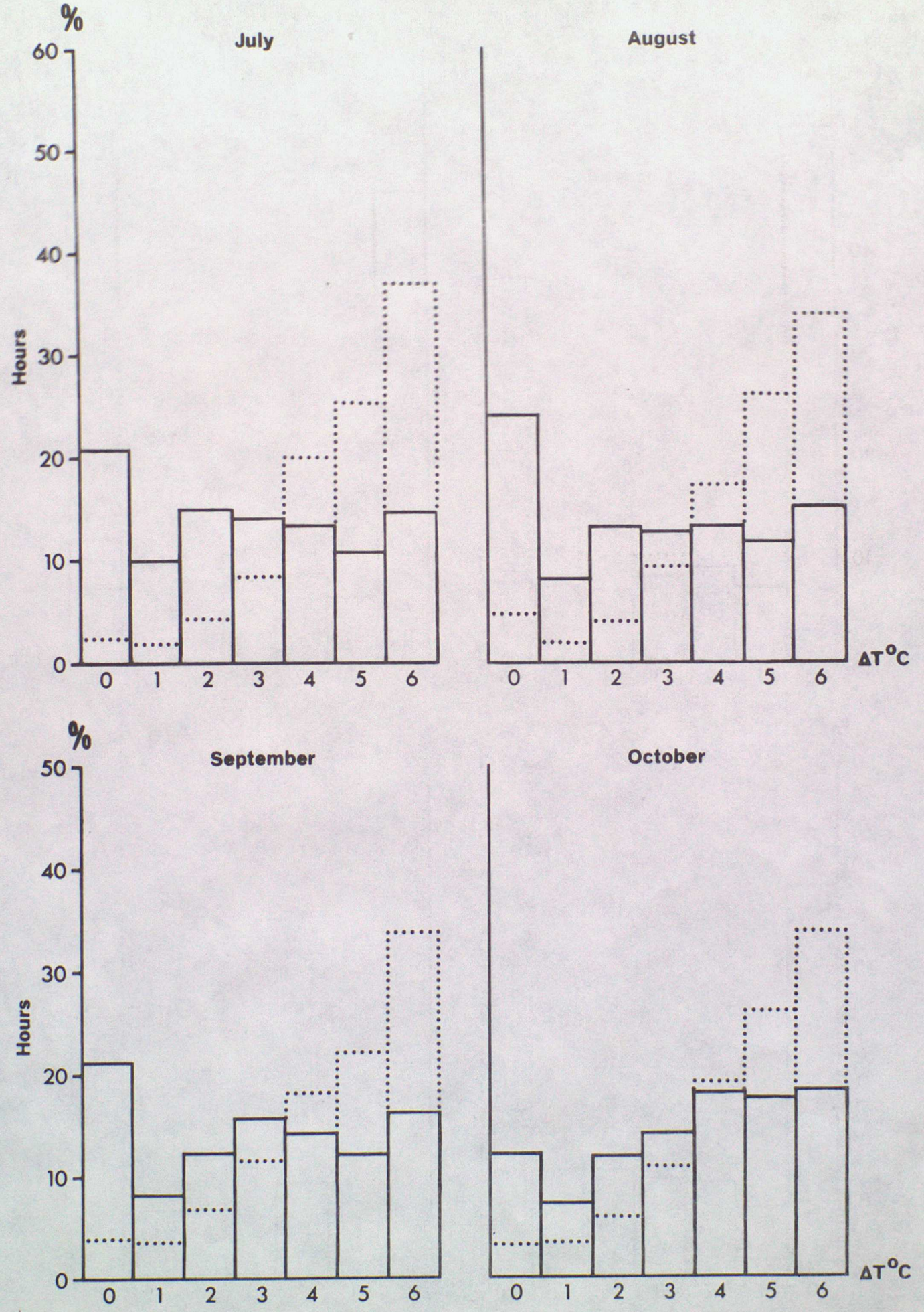

Fig.8

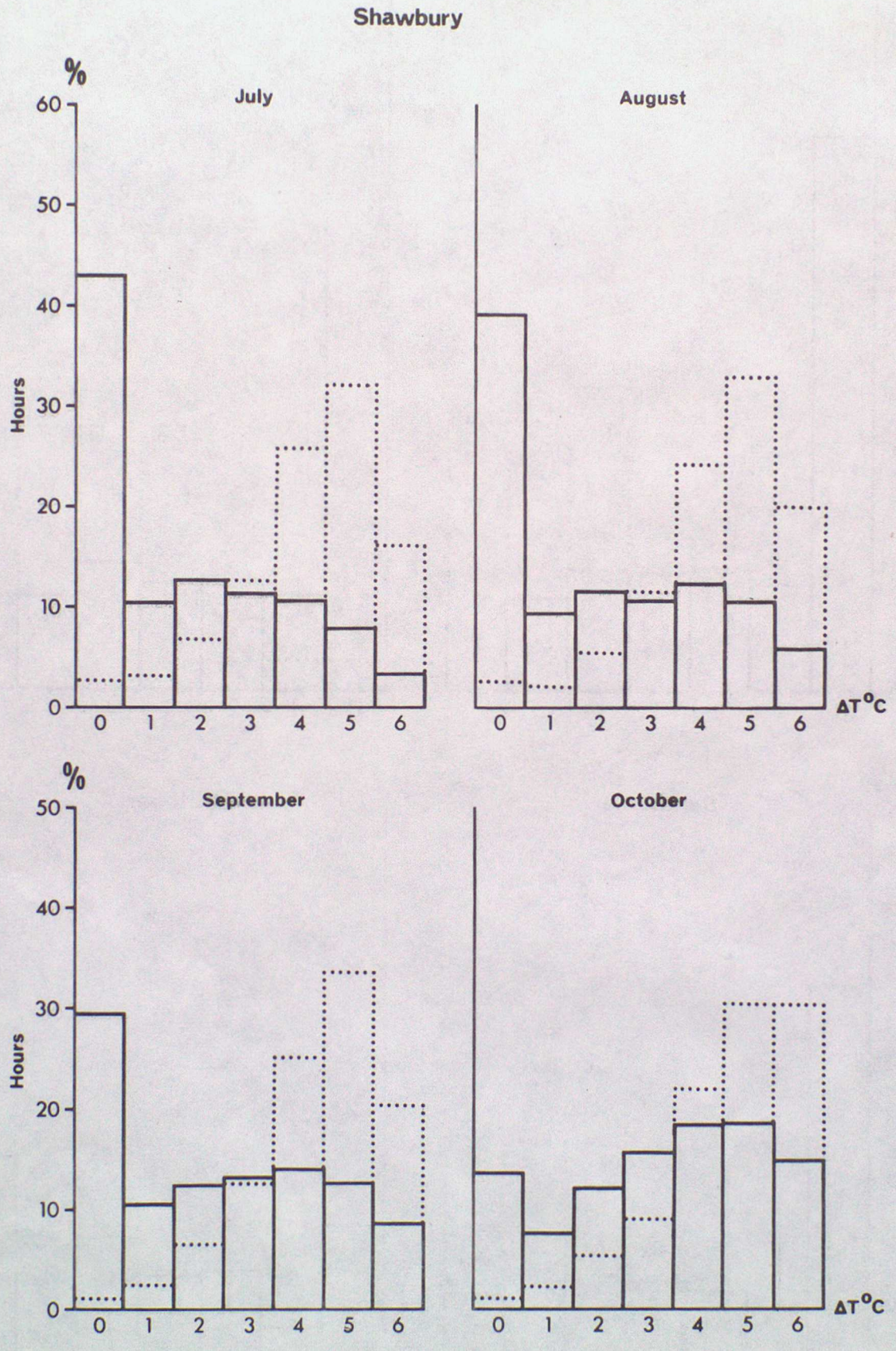
Shawbury
%
July
August
60
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C
%
September
October
50
40
30
20
10
0
Hours
0 1 2 3 4 5 6
ΔT°C

Fig.9

Waddington

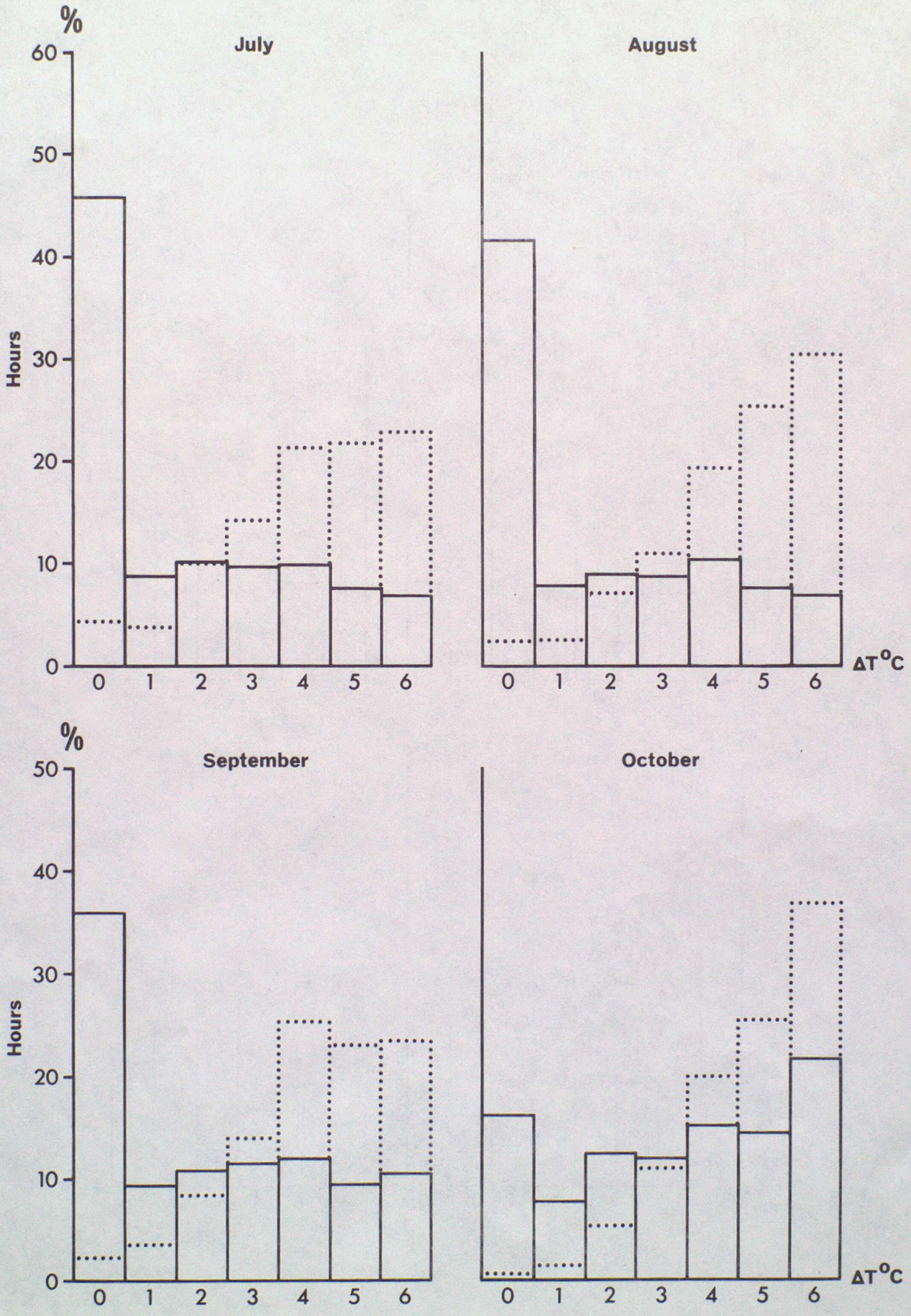

Fig. 10

Leeming
Blackpool Airport
Waddington
Shawbury
Birmingham (Elmdon)
Honington
Boscombe Down
Gatwick
Exeter Airport
St. Mawgan

Fig.11